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AN ADDENDUM TO ~~E151/227~~ and P545:

PROPOSAL TO STUDY NEUTRINO INTERACTIONS IN DEUTERIUM

IN THE 15-FOOT BUBBLE CHAMBER WITH PLATES

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I. INTRODUCTION

In this addendum we present a brief update to our approved experiments E151/227 and our proposal P545 to study neutrino-deuterium interactions in the 15-foot bubble chamber. On the assumption that the test of plates in this chamber, scheduled for April 1978, will be successful, we emphasize how plates would be useful in meeting many of our physics objectives, noting that the configuration to be tested is essentially identical to that we proposed in P545.

Before going to the specific physics aspects we point out once again four particular advantages of running in deuterium:

1. The charged current event rate is three times greater than that in hydrogen simply because there are three times as many down quarks.

2. It is possible to separate and compare neutron and proton interactions for all channels for the same incident flux, both for charged current and neutral current events.

3. The reaction $\nu n \rightarrow \mu^- p$ allows for an absolute internal flux normalization.

4. Like hydrogen, but unlike heavy liquids, it is possible to make constrained fits for a large class of events.

II. PHYSICS

1) Di-lepton Events

The e^+ identifications of $\sim$ 95% provided by the plate system,[1] together with μ^- identification from the EMI, will enable us to detect a large fraction of the expected number of $\nu d \rightarrow \mu^- e^+ X$ events. The deuterium target will allow us to separate, on an event-by-event basis, di-lepton production from proton and neutron targets. Our understanding of the source of di-lepton events will be enhanced by knowledge of their production rates from valence quarks, and sea quarks, which we can obtain directly from relative production rates from proton and neutron targets.

2) Search for Charmed Baryons in the Non-Leptonic Decay Modes

We will search for charmed baryons which would be evident in distinctive topologies having V^o's, such as $C_o^+ \rightarrow \Lambda^o\ \pi^+(\pi^+\pi^-)$ or $C_o^+ \rightarrow K_s^o\ p(\pi^+\pi^-)$. In this experiment we expect both a smaller combinational background and a better mass resolution than in the searches for charm particles in neon.

The plates would provide a γ-ray shower signature to separate ambiguous Λ/γ Vee's. Furthermore, a γ-ray veto criterion would help isolate a pure sample of fitted 3C quasi-elastic events, such as $\nu_\mu n \rightarrow C_o^+ \mu^-$.

3) Neutral Current Events

(i) A combination of the EMI, hadron interactions in the plates and liquid, and an application of the statistical B-C-M method should allow us to determine the ratio of n.c./c.c. events for neutrons and protons separately. (ii) It is our objective also to isolate a sample of neutral current events,

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[1] D. Carmony, Document to T. Groves, dated NOv. 9, 1927.

$\nu_\mu n \rightarrow \nu_\mu + X_h$, and compare the characteristics of neutron and proton target events. (iii) By measuring the energy of photons converted in the plates it is possible to improve the determination of momentum and energy of the hadronic portion of the final state.

The plates will also be useful in searching for exclusive neutral current reactions such as $\nu_\mu n \rightarrow \nu_\mu p\pi^-(\pi^+\pi^-)$.

4) Study of the Charged Current Events

These events would appear in the channels $\nu_\mu n \rightarrow \nu^- + X^+$ and $\nu_\mu p \rightarrow \mu^- + X^{++}$ which can be separated on an event by event basis for the majority of the sample. All physical quantities of interest in the inclusive sample, such as, total cross sections, Q^2 distribution, x distribution, v distribution scale breaking effects and average multiplicites, can be studied for protons and neutrons separately, thus providing a detailed test of the quark parton model predictons. In addition we will study low multiplicity exclusive channels, for which the downstream plates will provide valuable information, particularly as a γ-veto.

5) Flux Determination and Quasi-Elastic Reactions

Since the cross section for the charged-current quasi-elastic reaction $\nu_\mu n \rightarrow \mu^- p$ is energy-independent, these events provide an absolute measure of the neutrino flux in our experiment. The three-constraint fits $\nu_\mu\ d \rightarrow \mu^- pp_s$ will be used to isolate candidates for the quasi-elastic reaction; false fits will be eliminated by the observation of pointing gammas in the downstream plates yielding a much purer sample.

III. THE EXPOSURE

Our collaboration is presently approved for 200,000 pictures in a bare deuterium chamber and we have requested an additional exposure of 300,000 with plates. If the plate test is successful and a decision is made to run with plates in 1978, then, in order to compensate for the reduced primary interaction volume and to achieve the same physics goals, we request approval for an exposure of 500,000 pictures with plates. In Table I we give an updated set of event rates for a 500,000 picture experiment with plates.

Of course, if the plate test in the Spring of 1978 is unsuccessful, then we expect and are eager to run our approved 200,000 picture exposure with ν_μ in the bare bubble chamber filled with deuterium.

TABLE I. Neutrino + Deuterium Event Rates

Reaction	Events* in 500K Pictures
$\nu_\mu p \to \mu^- X$	15,000
$\nu_\mu n \to \mu^- X$	29,000
$\nu_\mu p \to \nu_\mu X$	3,500
$\nu_\mu n \to \nu_\mu X$	3,500
$\nu_\mu \begin{Bmatrix} p \\ n \end{Bmatrix} \to \Lambda^o(\text{Visible})X$	1,800
$\nu_\mu \begin{Bmatrix} p \\ n \end{Bmatrix} \to K^o_s(\text{Visible})X$	1,900
$\nu_\mu \begin{Bmatrix} n \\ p \end{Bmatrix} \to \mu^- + \text{Charm}$	2,000
$\nu_\mu p \to \mu^- e^+ X^+$	90
$\nu_\mu n \to \mu^- e^+ X^o$	180
$\nu_\mu n \to \mu^- p$	900
$\nu_\mu p \to \mu^- p \pi^+$	1,100
$\nu_\mu n \to \mu^- p \pi^o,\ \mu^- n \pi^+$	900
TOTAL ν_μ + D	50,000

*We assume 1.0 x 10^{13} p/pulse, and take the upstream 2/3 of the chamber as fiducial volume, and $(\Sigma p_x) \geq 9$ GeV (5 GeV) for charged (neutral) current events.